WE CLAIM:

1. A reversible photo-bleachable material comprising semiconductor nano-sized particles.

2. The material of claim 1 wherein said semiconductor comprises: C, Si, Ge, CuCl, CuBr, CuI, AgCl, AgBr, AgI, Ag_2S, CaO, MgO, ZnO, $Mg_xZn_{1-x}O$, ZnS, HgS, ZnSe, CdS, CdSe, CdTe, HgTe, PbS, BN, AlN, GaN, , $Al_xGa_{1-x}N$, GaP GaAs, GaSb, InP, InAs, $In_xGa_{1-x}As$, SiC, $Si_{1-x}Ge_x$, Si_3N_4, ZrN, CaF_2, YF_3, Al_2O_3, SiO_2, TiO_2, Cu_2O, Zr_2O_3, ZrO_2, SnO_2, YSi_2, $GaInP_2$, Cd_3P_2, Fe_2S, Cu_2S, $CuIn_2S_2$, MoS_2, In_2S_3, Bi_2S_3, $CuIn_2Se_2$, In_2Se_3, HgI_2, PbI_2 and their various isomers and alloys.

3. The material of claim 1 wherein said nano-particles are in spherical, cubical, rod-like, tetragonal, single or multi-wall nano-tube or other nano-scale geometric shapes.

4. The material of claim 1 wherein said nano-particles are immersed in polymer matrix or other chemicals.

5. The materials of claim 1 wherein the nano-particles are doped with other elements.

6. The materials of claim 1 wherein the nano-particles are coated with other semiconductors or chemicals.

7. A method of using reversible photo-bleachable material to create images or patterns with higher resolution than diffraction limit allows.

8. A method of adjusting the relaxation time of the reversible photo-bleachable material comprising a mechanism to separate at least part of the photo-generated electrons and holes.

9. A method of claim 8 wherein said mechanism comprises providing carrier accepting surface states in said nano-particles.

10. A method of claim 8 wherein said mechanism comprises providing chemical surfactant at the surface of said nano-particles.

11. A method of claim 8 wherein said mechanism comprises providing two types of nano-particles with different band-gaps.

12. A method of claim 8 wherein said mechanism comprises providing coating of another semiconductor with different band-gap at the surface of said nano-particles.

13. A method of claim 8 wherein said mechanism comprises providing n-type nano-particle in a p-type polymer matrix.

14. A method of claim 8 wherein said mechanism comprises providing p-type nano-particle in an n-type polymer matrix.

15. A method of claim 8 wherein said mechanism comprises providing n-type nano-particle or p-type nano-particles in a non-doped polymer matrix.

16. A method of claim 8 wherein said mechanism comprises Auger recombination of multiple electron and hole pairs in said nano-particles.

17. A method of exposing a substrate having a photoresist thereon, said method comprising:

providing R-CEL based on reversible photo bleachable material on said substrate; and

illuminating said photoresist with at least one light pattern, said R-CEL bleaches in response to said illuminating.

18. The method of claim 17 wherein said providing comprises applying a R-CEL layer including nano-particles on said photoresist, and said illuminating includes passing incident light through said nano-particle layer before it reaches at least part of said photoresist.

19. The method of claim 17 wherein said illuminating comprises providing multiple exposures separated in time.

20. The method of claim 19 further including allowing said R-CEL to relax between at least some of said multiple exposures.

21. The method of claim 17 wherein said illuminating comprises providing multiple different exposure patterns separated in position on said substrate.

22. The method of claim 21 further including allowing said nano-particles to relax between at least some of said multiple exposures.

23. The method of claim 17 wherein said illuminating step comprises using a programmable mask.

24. The method of claim 23 further including reprogramming said programmable mask to provide at least first and second different exposure patterns, and allowing said nano-particles to at least partially relax after exposure with said first pattern and before exposure with said second pattern.

25. The method of claim 17 wherein said illuminating step comprises using multiple fixed masks.

26. The method of claim 17 wherein said exposing process is carried out in liquid-immersion or solid-immersion.

27. The method of claim 17 wherein said providing mechanism includes spinning, spraying, rinsing, dipping, precipitation, evaporation and other thin-film deposit mechanisms.

28. The system of claim 17 wherein said reversible photo bleachable material comprise plural different types of nano-particles.

29. The system of claim 17 wherein said reversible photo bleachable material comprise multiple layers containing nano-particles.

30. A method of inspecting a lithography mask, said method comprising:

providing R-CEL based on reversible photo-bleachable material on said mask; and

photo detectors detecting reflection or transmission of illumination of said mask.

31. The method of claim 30 wherein said illumination passes though a layer including said nano-particles before reaching said mask.

32. A method of writing a lithography mask blank having a photoresist thereon, said method includes:

providing R-CEL based on reversible photo-bleachable material on said mask blank; and

illuminating said photoresist with at least one light pattern, said R-CEL photo-bleaches in response to said illuminating.

33. The method of claim 32 wherein said light passes through a layer including said nano-particles before reaching said photoresist.

34. An optical storage device comprising:

a substrate having optically-scannable information-bearing indicia thereon; and

a reversible contrast enhancement layer based on reversible photo-bleachable material disposed on at least part of said substrate.

35. The optical storage device of claim 34 wherein said reversible contrast enhancement layer contains nano-particles.